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RESEARCH ARTICLE

PRELIMINARY MODELING OF THE TIME VARIATION OF THE MONTHLY MEANS OF SOME CLIMATIC PARAMETERS IN SOME LOCALITIES OF CHAD

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ABSTRACT

In this paper we investigate the best fitting formulas of the time variation of the monthly means of some climatic parameters in the localities of Moundou, N'djaména, Pala and Sarh in the southern part of Chad. We have obtained that the insolation can be fitted by a quadratic function while the minimal, normal and maximal temperatures, minimal and maximal relative humidity of the air can be fitted by cubic functions. The degree of fitness of the empirical formulas generated by their corresponding models were at most one order less the empirical and theoretical values of the considered parameter, indicating that they can be used in operative works to fill missed data in chronological series.

INTRODUCTION

Nowadays, the climate change has brought more and more catastrophes in many parts of the world with tremendous social, economic and ecologic consequences, (Benjamin S. *et al*., 2015; Centre regional Agrhymet, 2010). This situation has forced many scientists around the world to carry multidisciplinary investigations on climate in order to better understand its variations and successfully prevent, and even avoid, their catastrophic effects, (Laila A. *et al*. 2011). Investigations on this theme have been done in many countries. In the first group of these countries, developed ones, the climate and its tendencies have been well-studied. For the second group, such studies are already going on. For the third and last group, the investigation structure has just been put in place. Despite the tremendous effort already made, the developed countries are still under frequent devastating influences of tropical cyclones, tsunamis, flogs, between others. For what concerns the developing countries, many are still to be done, but the situation varies from one country to another. In the western and northern parts of Africa, some studies highlighted the climate change and their consequences in these regions, (Benjamin S. *et al*., 2015; Joelle P., 2009; Centre Regional AGRHYMET, 2010, Laila A. *et al*., 2011)).

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Some simulations of this have been tried, (Césaire P. G. *et al*., 2011; Gil M., 2006; Koffi E. K. *et al*., 2014). Chad, a developing sahelian country, faces many of these problems. Moreover, it has not known peace for years. Consequently, the chronological sets of data of all meteorological parameters are roughly regular. They contain a lot of missed data. Thus, our results should be considered as preliminary and should be completed when full and regular bank of data will be available. This study investigates fitting functions for the time variation of the monthly means of some climatic parameters in some localities of Chad, namely Moundou, N'djaména, Pala and Sarh all situated in the southern part of the country. Later on, these empirical functions should be used to estimate the missing data of the considered parameters. Thus, a set of chronological regular data will be established for further more detailed investigations. This work is divided into four sections and the references presented in an alphabetic order. The first and present section is an introduction to the problem to be solved. The second exposes the data and the methodology. The third presents the results and their analysis. The fourth is the conclusion and recommendation.

DATA AND METHODOLOGY

Data: Our data comes from the meteorological stations situated at the airports in the above mentioned cities No doubt that they are well-equipped with good-trained personnel. It concerns the monthly means of the insolation, minimal, normal and maximal temperatures of the air, minimal and maximal relative humidity of the air. They were obtained from the numerical treatment of the many years daily observations of each parameter. They are presented in tabular forms and have been graciously given to us by the National Service of Meteorology of Chad in N'djaména. Their preliminary critical examination has permitted us to eliminate not coherent ones. It is then understandable why the periods covered by the data are different. The longest period of coverage goes from 1971 to 2004 and the shortest, from 1988 to 2002. Thus, the used data can be considered as representative.

Methodology

In order to facilitate computations, a facultative variable, t, was introduced such that January corresponds to t = -11, February, to t = -9, March, to t = -7, and so on, November, to t = 9 and December, to t = 11. So, we have a sequence of an arithmetic progression with the first number -11, the ratio 2 and the last number 11. Letting y the considered climatic parameter, experimental points M(t,y) were placed in a coordinate axes with t, the time, on the ox axis and y, the monthly mean of the climatic parameter – on the oy axis. Thus, we have obtained clouds of points and the analysis of their configuration has permitted us to find out the form of relationship between the variables t and y.

Then using the least squared method gave us the analytic expression of the fitting function. Each fitting function was used to find the theoretical value of the corresponding parameter, y_{th}. To appreciate the correctness of the obtained formula, the degree of fitness, ε, of each formula was computed as the difference between the experimental, y_{exp}, and theoretical, y_{th}, values of the corresponding parameter, $\varepsilon = y_{th} - y_{exp}$, and its absolute value considered, $|\varepsilon|$.

RESULTS AND ANALYSIS

Following the procedure exposed in point 2.2 of the second section, we have obtained the next results.

Insolation (I, in hours/day)

From the analysis of clouds of points of all the stations, it comes that the relationship, I (t), between t and I is quadratic. Their analytic expressions are as follows.

For the station of Moundou: $I(t) = 0.02815\ t^2 + 0.01346\ t + 8.2$.
For the station of N'djaména: $I(t) = 0.01178\ t^2 + 0.00367\ t + 8.4$.
For the station of Pala: $I(t) = 0.02357\ t^2 + 0.00087\ t + 6.8$.
For the station of Sarh: $I(t) = 0.02013\ t^2 + 0.03530\ t + 6.5$.

The results of simulation are contained in Table 3.1. From Table 3.1 it comes that the interval of variation of the duration of the sunshine in all the stations was $5.7 \leq I < 11.9$. The longest duration was observed during the dry season in the interval $7.5 \leq I \leq 11.9$ hours/day, i.e. from January to May and from October to December.

Table 3.1. Results of simulation of the insolation

Mois	t	Moundou			N'djaména			Pala			Sarh		
		I_{exp}	I_{th}	$\|\varepsilon\|$.	I_{exp}	I_{th}	$\|\varepsilon\|$	I_{ecp}	I_{th}	$\|\varepsilon\|$	I_{exp}	I_{th}	$\|\varepsilon\|$
January.	-11	10.1	11.5	1.4	9.4	9.9	0.5	9.0	9.7	0.7	8.5	9.3	0.8
February	-9	10.6	10.4	0.2	9.5	9.4	0.1	9.1	8.7	0.4	8.5	8.4	0.1
March	-7	9.6	9.5	0.1	9.0	9.0	0.0	8.0	8.0	0.0	7.9	7.7	0.2
April	-5	11.1	8.8	2.3	9.0	8.7	0.3	8.0	7.4	0.6	8.1	7.2	0.9
May	-3	9.2	8.4	0.8	9.1	8.5	0.6	7.7	7.0	0.7	7.5	6.8	0.7
June	-1	8.6	8.2	0.4	8.9	8.4	0.5	7.3	6.8	0.5	6.7	6.6	0.1
July	1	7.4	8.2	0.8	7.6	8.4	0.8	6.3	6.8	0.5	5.7	6.5	0.8
August	3	7.0	8.5	1.5	7.4	8.5	1.1	6.1	7.0	0.9	5.7	6.6	0.9
September	5	7.6	9.0	1.4	8.4	8.7	0.3	6.4	7.4	1.0	6.1	6.8	0.7
October	7	10.1	9.7	0.4	9.5	9.0	0.5	8.5	7.9	0.6	7.2	7.2	0.0
November	9	11.8	10.6	1.2	9.8	9.3	0.5	9.7	8.7	1.0	8.5	7.8	0.7
December	11	11.9	11.8	0.0	9.5	9.8	0.3	9.4	7.0	2.4	8.6	8.5	0.1

Table 3.2. Results of simulation of the minimal temperature

Mois	t	Moundou			N'djaména			Pala			Sarh		
		$T_{min,exp}$	$T_{min,th}$	$\|\varepsilon\|$	$T_{min,exp}$	$T_{min,th}$	$\|\varepsilon\|$	$T_{min,exp}$	$T_{min,th}$	$\|\varepsilon\|$	$T_{min,exp}$	$T_{min,th}$	$\|\varepsilon\|$
January.	-11	15.7	16.1	0.4	14.5	14.0	0.5	16.2	16.1	0.1	19.4	19.7	0.3
February	-9	18.9	19.4	0.5	17.2	18.6	1.4	18.6	19.7	1.1	22.1	22.7	0.6
March	-7	22.7	21.7	1.0	21.9	21.9	0.0	23.3	22.1	1.2	25.7	24.7	1.0
April	-5	24.5	23.1	1.4	25.6	24.1	1.5	25.5	23.4	2.1	27.3	25.7	1.6
May	-3	23.8	23.6	0.2	26.3	25.7	0.6	24.4	23.9	0.5	26.1	26.0	0.1
June	-1	22.3	23.6	1.3	25.2	25.5	0.3	22.4	23.7	1.3	24.6	25.6	1.0
July	1	21.3	22.9	1.6	23.7	25.1	1.4	21.6	23.0	1.4	23.3	24.9	1.6
August	3	21.2	21.9	0.7	22.6	24.0	1.4	21.2	21.8	0.6	23.2	23.9	0.7
September	5	20.9	20.5	0.4	23.0	22.4	0.6	21.2	20.5	0.7	23.2	22.8	0.4
October	7	21.0	18.9	2.1	22.2	20.5	1.7	21.4	19.1	2.3	23.7	21.8	1.9
November	9	17.5	17.2	0.3	18.4	21.3	2.9	18.1	17.8	0.3	21.5	21.0	0.5
December	11	14.6	15.6	1.0	15.4	16.0	0.6	16.0	16.8	0.8	19.7	20.7	1.0

The shortest one occurred in the rainy season in the interval$5.7 \leq I < 7.5$ hours/day.In general, the insolation was decreasing from January to its minimal value in July – August, then it started increasing to its maximal value in December. This time variation was due to the evolution of the clouds which are less during the dry season and a lot in the rainy season.

In general, the degree of fitness of all the models was at most one order less than their corresponding empirical and theoretical values. Thus the obtained models are acceptable.

A. **Temperature (T, in °C)**

The analysis of clouds of points generated by this parameter has shown a cubic relationship, T(t), between variables t and T. Their analytic expressions are as follows.

Minimal temperature (T_{min}, in °C)

For the station of Moundou: $T_{min}(t) = 0.00243\ t^3 - 0.06135\ t^2 + 0.31723\ t + 23.3$.
For the station of N'djaména: $T_{min}(t) = 0.00268\ t^3 - 0.08599\ t^2 + 0.23275\ t + 25.4$.
For the station of Pala: $T_{min}(t) = 0.00338\ t^3 - 0.05764\ t^2 + 0.37789\ t + 23.4$.
For the station of Sarh: $T_{min}(t) = 0.00357\ t^3 - 0.04213\ t^2 + 0.38472\ t + 25.3$.
The results of simulation are contained in Table 3.2.

Normal temperature, (T_{moy}, °C)

For the station of Moundou: $T_{moy}(t) = 0.00483\ t^3 - 0.01515\ t^2 + 0.58673\ t + 27.9$.
For the station of N'djaména: $T_{moy}(t) = 0.00527\ t^3 - 0.05014\ t^2 + 0.51630\ t + 31.1$.

Maximal temperature, (T_{max}, C)

For the station of Moundou: $T_{max}(t) = 0.00674\ t^3 - 0.01048\ t^2 + 0.79707\ t + 33.0$.
For the station of N'djaména: $T_{max}(t) = 0.00594\ t^3 - 0.03449\ t^2 + 0.59025\ t + 33.3$.
For the station of Pala: $T_{max}(t) = 0.00631\ t^3 - 0.02912\ t^2 + 0.70809\ t + 29.1$.
For the station of Sarh: $T_{max}(t) = 0.00357\ t^3 - 0.04184\ t^2 + 0.38916\ t + 26.2$.
The results of simulation are contained in Table 3.4.

Table 3.2 indicates that higher values of minimal temperature occurred during the period between June and August and lower ones – around January and December. This distribution of the minimal temperature of the air was due to the penetration to the region of the winter mass of air from the polar northern hemisphere areas.

From Tables 3.3 – 3.4 it comes that higher values of normal and maximal temperatures were observed in the period March-April and October-November when the insolation is higher and the sunshine - intense.

In general almost all the values of the degree of fitness of these formulas were at most one order less the values of the corresponding parameters. Thus, the obtained models are acceptable.

Table 3.3. Results of simulation of the normal temperature

Mois	**t**	**Moundou**			**N'djaména**			**Pala**			**Sarh**		
		$T_{moy,exp}$	$T_{moy,th}$	$\lvert\varepsilon\rvert$	$T_{moy,exp}$	$T_{moy,th}$	$\lvert\varepsilon\rvert$	$T_{moy,exp}$	$T_{moy,th}$	$\lvert\varepsilon\rvert$	$T_{moy,exp}$	$T_{moy,th}$	$\lvert\varepsilon\rvert$
January.	-11	25.8	26.1	0.3	23.8	23.7	0.1	25.0	25.2	0.2	26.3	26.8	0.5
February	-9	27.4	28.4	1.0	26.5	27.8	1.3	26.7	28.3	1.6	28.6	29.3	0.7
March	-7	31.3	29.6	1.7	30.9	30.4	0.5	31.4	29.8	1.6	31.7	30.6	1.1
April	-5	31.1	29.9	1.2	33.8	31.8	2.0	32.3	30.3	2.0	32.4	30.8	1.6
May	-3	29.4	29.4	0.0	33.3	32.1	1.2	30.0	29.8	0.2	30.2	30.2	0.0
June	-1	27.4	26.5	1.1	31.0	31.6	0.6	27.5	28.8	1.3	28.1	29.2	1.1
July	1	25.9	27.3	1.4	28.4	30.5	2.1	25.5	27.5	2.0	26.2	28.0	1.8
August	3	25.2	26.1	0.9	26.9	29.2	2.3	25.0	26.3	1.3	25.8	26.7	0.9
September	5	25.6	25.2	0.4	28.0	27.9	0.1	25.6	25.3	0.3	26.3	25.8	0.5
October	7	26.4	24.7	1.7	29.9	26.8	3.1	27.0	25.0	2.0	27.2	25.5	1.7
November	9	26.0	24.9	1.1	27.7	26.2	1.6	27.2	25.5	1.7	27.2	26.2	1.0
December	11	24.7	26.0	1.3	24.5	26.4	1.9	25.3	27.2	1.9	26.2	28.0	1.8

Table 3.4 Results of simulation of the maximal temperature

Mois	t	Moundou			N'djaména			Pala			Sarh		
		$T_{max;exp}$	$T_{max;th}$	$\lvert\varepsilon\rvert$	$T_{max;exp}$	$T_{max;th}$	$\lvert\varepsilon\rvert$	$T_{max;exp}$	$T_{max;th}$	$\lvert\varepsilon\rvert$	$T_{max;exp}$	$T_{max;th33.0}$	$\lvert\varepsilon\rvert$
January.	-11	33.0	34.1	1.1	28.0	27.7	0.3	24.7	25.0	0.3	20.4	20.7	0.3
February	-9	36.2	36.1	0.1	30.4	31.5	1.1	27.1	28.5	1.4	22.9	23.7	0.8
March	-7	38.4	36.8	1.6	34.0	33.7	0.3	32.1	30.5	1.6	26.4	25.6	0.8
April	-5	38.2	36.4	1.8	36.3	34.6	1.7	33.5	31.1	2.4	28.2	26.7	1.5
May	-3	35.3	35.3	0.0	35.6	34.6	1.0	31.2	30.8	0.4	27.2	26.9	0.3
June	-1	32.3	33.8	1.5	33.5	33.8	0.3	28.3	29.8	1.5	25.3	26.5	1.2
July	1	30.2	32.2	2.0	30.4	32.7	2.3	25.9	28.4	2.5	24.2	25.8	1.2
August	3	29.5	30.9	1.4	28.3	31.4	3.1	25.4	26.9	1.6	24.0	24.8	0.8
September	5	30.8	30.1	0.7	30.0	30.2	0.2	26.5	25.6	0.9	23.9	23.7	0.2
October	7	32.6	30.2	2.4	32.6	29.5	3.1	27.4	24.9	2.5	24.5	22.7	1.8
November	9	33.6	31.6	2.0	31.5	29.5	2.0	26.4	25.0	1.4	22.4	21.9	0.5
December	11	32.3	34.5	2.2	28.7	30.5	1.8	24.3	26.2	1.9	20.5	21.6	1.1

For the station of Pala: $T_{moy}(t) = 0.00611\ t^3 - 0.01635\ t^2 + 0.64764\ t + 28.2$.
For the station of Sarh: $T_{moy}(t) = 0.00558\ t^3 - 0.01130\ t^2 + 0.63316\ t + 28.6$.
The results of simulation are contained in Table 3.3.

B. Relative humidity of the air (f, in %)

It comes from the analysis of its clouds of points that the relationship, f(t), between the time t and f is of cubic form. Their analytic expressions are as follows.

Table 3.5 Results of simulation of the minimal relative humidity of the air

Mois	t	Moundou			N'djaména			Pala			Sarh		
		$f_{min,exp}$	$f_{min,th}$	$\|\varepsilon\|$	$f_{min,exp}$	$f_{min,th}$	$\|\varepsilon\|$	$f_{min,exp}$	$f_{min,th}$	$\|\varepsilon\|$	$f_{min,exp}$	$f_{min,th}$	$\|\varepsilon\|$
January.	-11	13	12	1	13	12	1	12	7	5	13	11	2
February	-9	19	14	5	10	9	1	10	11	1	11	13	2
March	-7	13	20	7	9	11	2	11	19	8	17	20	3
April	-5	24	29	5	13	17	4	26	30	4	26	29	3
May	-3	38	38	0	21	24	3	43	41	2	39	39	0
June	-1	50	47	3	29	32	3	55	52	3	49	48	1
July	1	59	54	5	45	39	6	65	60	5	59	55	4
August	3	61	58	3	56	43	13	68	63	5	61	59	2
September	5	57	57	0	47	43	4	61	61	0	57	58	1
October	7	46	49	3	22	37	15	47	52	5	48	50	2
November	9	24	34	10	12	24	12	20	34	14	27	35	8
December	11	17	10	7	12	11	1	15	5	10	16	11	5

Table 3.6 Results of simulation of the maximal relative humidity of the air

Mois	t	Moundou			N'djaména			Pala			Sarh		
		$f_{max,exp}$	$f_{max,th}$	$\|\varepsilon\|$	$f_{max,exp}$	$f_{max,th}$	$\|\varepsilon\|$	$f_{max,exp}$	$f_{max,th}$	$\|\varepsilon\|$	$f_{max,exp}$	$f_{max,th}$	$\|\varepsilon\|$
January.	-11	55	46	9	40	35	5	31	24	7	54	49	5
February	-9	39	50	11	33	32	1	25	30	5	45	52	7
March	-7	50	58	8	29	37	8	27	41	14	52	59	7
April	-5	71	67	4	41	46	5	55	54	1	67	68	1
May	-3	82	77	5	61	58	3	78	69	9	83	78	5
June	-1	93	87	6	75	71	4	88	82	6	91	88	3
July	1	97	95	2	89	82	7	93	93	0	97	96	1
August	3	98	100	2	94	89	5	95	93	3	98	101	3
September	5	97	101	4	93	89	4	95	97	2	98	103	5
October	7	96	97	1	75	81	6	88	87	1	97	99	2
November	9	86	88	2	45	62	17	58	67	9	90	89	1
December	11	74	71	3	42	29	13	40	34	6	70	70	0

Minimal relative humidity, (f_{min} in %)

For the station of Moundou: $f_{min}(t) = -0.03077\ t^3 - 0.32961\ t^2 + 3.59993\ t + 51$.
For the station of N'djaména: $f_{min}(t) = -0.03290\ t^3 - 0.24269\ t^2 + 3.47644\ t + 36$.
For the station of Pala: $f_{min}(t) = -0.03411\ t^3 - 0.41240\ t^2 + 4.00924\ t + 56$.
For the station of Sarh: $f_{min}(t) = -0.03016\ t^3 - 0.34222\ t^2 + 3.65603\ t + 52$.
The results of simulation are contained in Table 3.5.

Maximal relative humidity of the air, (f_{max}, C).

For the station of Moundou: $f_{max}(t) = -0.02364\ t^3 - 0.27223\ t^2 + 3.99764\ t + 91$.
For the station of N'djaména: $f_{max}(t) = -0.04793\ t^3 - 0.37144\ t^2 + 5.51646\ t + 77$.
For the station of Pala: $f_{max}(t) = -0.03951\ t^3 - 0.48745\ t^2 + 5.24503\ t + 88$.
For the station of Sarh: $f_{max}(t) = -0.02677\ t^3 - 0.26786\ t^2 + 4.20238\ t + 92$.
The results of simulation are contained in Table 3.6.

Tables 3.5 – 3.6 show that lower values of relative humidity of the air for all the stations occurred in January and December and higher ones – in the period from June to September. This distribution was can be explained by the repartition of the seasons. From June to September – October we have the rainy season with wet and humid mass of air while the remaining period of the year is occupied by the dry season with dry mass of air. Some oversaturation of the air, f> 100%, were observed in Moundou in September with f = 101%, in Sarh in August and September with respectively 101 and 103%. In general almost all the values of the degree of fitness of the formulas were at most one order less the empirical and theoretical values of the relative humidity of the air and consequently, the models are declared acceptable.

Conclusion and recommendation

Almostall the theoretical values of all the parameters were closer to their corresponding experimental ones. The lower values of the degree of fitness of all the formulas confirm this fact. Hence, our models are useable in operative work to complete some missed data. No doubt that they should be improved when full and regular chronological bank of data will be available.

REFERENCES

Benjamin Sultan, Richard Lalou, Mouftaou Amadou Sanni, Amadou Oumarou et MameArameSoumaré, 2015. Les sociétés rurales face aux changements climatiques et environnementaux en Afrique de l'Ouest. Editions IRD ; Marseille, Collection Synthèses, 463p.

Césaire P. Gnanglé, Romain Glélé Kakai, Achille E. Assogbadjo, Samuel Vodounnon, Jacob AfoudaYabi, Nestor Sokpon, 2011. Tendances climatiques passées, modélisation, perceptions et adaptations locales au Bénin. Journal de l'Association Internationale de Climatologie, p. 27-40.

Joëlle Pomerleau, 2009. Changements climatiques et sécurité en Afrique. Essai effectué en vue de l'obtention du grade de maitre en environnement sous la direction de Rosa Ortiz, Université de Sherbrooke, 99p.

Centre Régional AGRHYMET, 2010. Le sahel face aux changements climatiques. Enjeux pour le développement durable. Bulletin mensuel, numéro spécial, 42p.

Gil Mahé, 2006. Variabilité pluie-débit en Afrique de l'Ouest et Centrale au 20e siècle : changements hydro-climatiques, occupation du sol et modélisation hydrologique. Mémoire habilitation à diriger des recherches, Université des Sciences et Techniques, Montpellier 2. Ecole doctorale 148 Terre, Eau, Espace, 160p.

Koffi Eugene Kouakou, Zile Alex Kouadio, Francis William Kouassi, Bi Tie Albert, Issiaka Savane, 2014. Modélisation de la température et de la pluviométrie dans un contexte de changement climatique : cas de l'Afrique de l'Ouest. Afrique Sciences, vol. 10 (1), http://www.afriquescience.info/document.php?id=3173. ISSN 1813-548X

Laila Amraoui, Mamadou AdamaSarr, Didier Soto, 2011. Analyse rétrospective de l'évolution climatique récente en Afrique du Nord-Ouest. Journal Physio-Géo, vol. 5, varia 2011, p. 125-142.

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